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Prevalences and Management of Diabetes and Pre-diabetes among Korean Teenagers and Young Adults: Results from the Korea National Health and Nutrition Examination Survey 2005–2014

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The rapid increases in childhood obesity and physical inactivity are linked to the incidence of diabetes among young individuals. However, few studies have evaluated the prevalence of diabetes among this population. Therefore, we used Korea National Health and Nutrition Examination Survey (KNHANES) data to evaluate the prevalence and management of diabetes and pre-diabetes among young Koreans. We evaluated KNHANES data (2005–2014) from 10–29-year-old individuals. Individuals were considered eligible if they had completed the health examination and the health interview survey, and we excluded individuals with missing data regarding fasting glucose or glycated haemoglobin levels. Among the 100,101 potentially eligible individuals who participated in KNHANES (2005–2014), we included 83,577 (37,677 male and 45,900 female) individuals. The overall prevalences of diabetes and pre-diabetes among 10–19-year-old individuals were 0.2% and 11.9%, respectively. Among 20–29-year-old individuals, the prevalences of diabetes and pre-diabetes were 0.9% and 9.6%, respectively. The overall rates of diabetes awareness during the study period were 36.6% for 10–19-year-old individuals and 50.8% for 20–29-year-old individuals. However, the prevalence of diabetes and pre-diabetes had noticeably increased at the 2013–2014 KNHANES: 0.6% and 25.9% among 10–19-year-old individuals, and 0.8% and 19.2% among 20–29-year-old individuals. The prevalence of diabetes and pre-diabetes is rapidly increasing among Korean teenagers and young adults. Pre-emptive interventions to diagnose and treat diabetes and pre-diabetes are needed to improve glycaemic control among this population.

Keywords: Diabetes Mellitus; Prediabetic State; Epidemiology; Health Care Surveys

INTRODUCTION

Type 1 diabetes is the most common form of diabetes among young people (1), although the incidence of type 2 diabetes is rapidly increasing because of the soaring trajectory of childhood obesity (2). Among teenagers and young adults, diabetes mellitus is considered as a relatively heterogeneous disease with complex etiologies, pathophysiology, clinical features, and complications (3). Based on the accelerating rates of obesity, children with type 1 diabetes are more likely to be overweight or obese, which makes it difficult to distinguish between type 2 diabetes and obese type 1 diabetes at the initial clinical visit (4,5). For example, one report found that the initial classification of diabetes was changed during the follow-up for 10% of childhood cases (6). Therefore, the rapid increases in childhood obesity and physical inactivity are linked to the incidence of diabetes among young people (7). One study reported that among the Korean children and adolescents aged 6–18 years old the prevalence of obesity increased from 6.8% in 1998 to 10.0% in 2013 (8). Another study showed that the prevalence of metabolic syndrome in Korean adolescents aged 12–19 years old was 2.5% in 2005 according to a national survey (9). However, few studies have evaluated the prevalence of diabetes among teenagers and young adults in Korea or many other countries.

Several studies have recently demonstrated that young people with type 2 diabetes exhibit more rapid deterioration in β-cell function (10), earlier presentation with complications (11-13), and greater mortality (13), compared to young people with type 1 diabetes and adults with type 2 diabetes (14). Furthermore, given the aggressive clinical course and much longer life expectancy in cases of early-onset diabetes, studies are urgently needed to evaluate the prevalence and management of diabetes among teenagers and young adults. Moreover, recognizing the present barriers to controlling glycaemic status, and optimizing β-cell

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preservation techniques, are crucial steps towards reducing morbidity and mortality among young people with diabetes (4). Therefore, the present study aimed to evaluate the prevalence and management of diabetes and pre-diabetes among young Koreans (10–29 years old).

MATERIALS AND METHODS

Data source and study sample

The Korea National Health and Nutrition Examination Survey (KNHANES) is a nationally-representative, population-based, cross-sectional survey of health and nutritional status among the Korean population. This survey is administered by the Korean Ministry of Health and Welfare, and consists of three distinct surveys: a health interview survey, a health examination survey, and a nutrition survey. Data from the Korea National Statistical Office are used to define the standard population, and sampling weights are used to account for the complex sampling to represent the entire non-institutionalized Korean population. The sample weights included three components: the probability of selection; an adjustment for non-response; and a post-stratification factor according to district, age, and sex category approximately equal to the total population of Korea (15,16). Furthermore, to avoid bias from longitudinal changes in the age and sex distributions, these factors were adjusted to reflect the Korean population distributions each year. All participants participate voluntarily and provide their informed consent for the data collection. The KNHANES protocol is approved by the Korean Ministry of Health and Welfare, and the study is performed in accordance with the guidelines of the Declaration of Helsinki.

In the present study, we collected data for individuals who were 10–30 years old and participated in four KNHANES cycles (2005, 2007–2009, 2010–2012, and 2013–2014). All individuals had completed both the health examination survey and the health interview survey, and we excluded any individuals with missing data regarding their fasting glucose or glycated haemoglobin (HbA1c) levels. All anthropometric measurements were performed by well-trained examiners, who used a standard protocol for all four KNHANES cycles.

Blood samples were collected at the mobile examination centers in the morning after fasting for at least 8hours. Total cholesterol, fasting plasma glucose, triglyceride, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, and serum creatinine levels were measured by Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan). HbA1c was measured using a high-performance liquid chromatography method (HLC-723G7; Tosoh, Tokyo, Japan).

Operational definitions

Diabetes and pre-diabetes were determined based on individual's levels of fasting plasma glucose and/or glycated haemoglobin. Diabetes cases in this study included both "known" and "new-onset" diabetes. Cases of known diabetes were identified based on a self-reported history of a clinical diagnosis of diabetes and/or the current use of anti-diabetic medication (e.g., insulin and oral hypoglycaemic agents). Cases of "new-onset diabetes" were identified based on the survey results providing the first indication of diabetes; fasting plasma glucose levels of ≥ 7.0 mmol/L (126 mg/dL) and/or HbA1c levels of 6.5% or higher (≥ 47 mmol/mol). Pre-diabetes was defined as fasting plasma glucose levels of 5.6–6.9 mmol/L (100–125 mg/dL) and/or HbA1c levels of 5.7%–6.5% (39–47 mmol/mol). Awareness of diabetes was defined as the proportion of known diabetes cases among all diabetes cases. The proportion of individuals with adequate glucose control was defined as the number of participants with HbA1c levels of 7.0% (53 mmol/mol), recommended by the European Association for the Study of Diabetes (EASD) and the American Diabetes Association (ADA), or 6.5% (47 mmol/mol), recommended by the Korean Diabetes Association (KDA), among all cases of known diabetes.

Obesity was diagnosed using the anthropometric data from each health examination. According to the Korean Society for the Study of Obesity, obesity is defined as a body mass index (BMI) of ≥ 25 kg/m^2 among individuals who are ≥ 19 years old. Among Korean children who are 10–18 years old, obesity is defined as a BMI that exceeds the 95th percentile of the age- and sex-specific BMI values.

Statistical analysis

To adjust the analysis for the complex sample and study design, we used the KNHANES sampling weight variables. Due to relatively small numbers of diabetes and pre-diabetes cases at some age groups, we only analysed variables with at least five valid counts in each category to avoid unexpectedly inflated results. Nominal variables were presented as the number and percentage, and continuous variables were presented as mean ± standard deviation. All analyses were performed using R software (version 3.3.0; R Project for Statistical Computing, Vienna, Austria; http://cran.r-project.org).

Ethics statement

All participants of the KNHANES provided written informed consent. The present study's retrospective design was approved by the Institutional Review Board of the Kangwon National University Hospital (KNUH-2016-07-007).

RESULTS

Prevalence of diabetes and pre-diabetes during KNHANES 2005–2014

Table 1 summarises the characteristics among Korean youth and young adults during the four KNHANES cycles separately

Table 1. Baseline characteristics among Korean participants aged between 10 and 30 years in KNHANES 2005–2014

Parameters	KNHANES year				
	2005	2007–2009	2010–2012	2013–2014	2005–2014
No. (total)	14,185,964	13,773,914	13,370,845	12,797,206	13,450,317
Men	7,399,682	7,210,022	7,024,982	6,742,319	7,056,979
Women	6,786,282	6,563,892	6,345,863	6,054,887	6,393,338
Age, yr	19.9 ± 5.9	19.8 ± 5.9	19.9 ± 5.8	19.9 ± 5.7	19.9 ± 5.8
BMI, kg/m^2	21.5 ± 3.7	21.7 ± 3.9	21.7 ± 4.0	21.9 ± 4.0	21.7 ± 3.9
SBP, mmHg	107.6 ± 11.4	105.9 ± 10.9	107.8 ± 11.2	108.9 ± 10.7	107.5 ± 11.0
DBP, mmHg	70.0 ± 9.7	68.7 ± 9.5	68.7 ± 10.1	69.0 ± 9.3	68.8 ± 9.7

Values are presented as number of participants or mean ± standard deviation. The numbers of counts in this table were calculated based on the weights designed to account for the complex design, non-response rate, and unequal probability of selection of sample participants to represent the whole population. The values for the periods with multiple years are the average values per year.
KNHANES = Korea National Health and Nutrition Examination Survey, BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure.

Table 2. Changes in prevalence of diabetes and pre-diabetes among Korean youth (aged between 10 and 30) in KNHANES 2005–2014

Diabetic groups by age	KNHANES year				
	2005	2007–2009	2010–2012	2013–2014	2005–2014
No. (total)	14,185,964	13,773,914	13,370,845	12,797,206	13,450,317
Prevalence of diabetes by age, No. (%)					
10–19	NA	8,333 (0.1)	7,208 (0.1)	33,917 (0.6)	13,358 (0.2)
20–29	36,584 (0.5)	60,122 (0.8)	72,665 (1.1)	55,221 (0.8)	60,627 (0.9)
10–29	39,832 (0.3)	68,455 (0.5)	79,873 (0.6)	89,139 (0.7)	73,984 (0.6)
Prevalence of pre-diabetes by age, No. (%)					
10–19	39,195 (0.6)	301,891 (4.6)	872,973 (13.5)	1,547,059 (25.9)	765,524 (11.9)
20–29	23,831 (0.3)	365,361 (5.1)	731,582 (10.8)	1,270,329 (19.2)	667,369 (9.6)
10–29	63,026 (0.4)	667,252 (4.8)	1,604,555 (12.1)	2,817,388 (22.4)	1,432,894 (10.7)

The numbers of counts in this table were calculated based on the weights designed to account for the complex design, non-response rate, and unequal probability of selection of sample participants to represent the whole population. The values for the periods with multiple years are the average values per year.
KNHANES = Korea National Health and Nutrition Examination Survey, NA = not available.

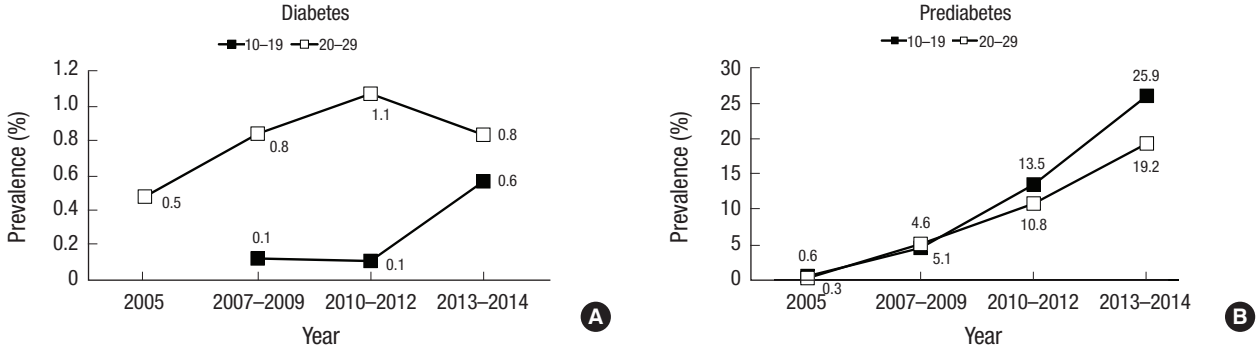

Fig. 1. Prevalence of diabetes and pre-diabetes during the four KNHANES cycles. (**A**) prevalence of diabetes, (**B**) prevalence of pre-diabetes.
KNHANES = Korea National Health and Nutrition Examination Survey.

(2005, 2007–2009, 2010–2012, and 2013–2014) and combined (2005–2014). The numbers of participants and prevalences of diabetes and pre-diabetes during these cycles are reported in Table 2. The overall prevalences of diabetes and pre-diabetes among 10–19-year-old individuals were 0.2% and 11.9%, respectively. The overall prevalences of diabetes and pre-diabetes among 20–29-year-old individuals were 0.9% and 9.6%, respectively. However, during the 2013–2014 KNHANES, the prevalences of diabetes and pre-diabetes among 10–19-year-old individuals increased to 0.6% and 25.9%, respectively. Similarly, among 20–29-year-old individuals, the prevalences of diabetes and pre-diabetes increased to 0.8% and 19.2%, respectively.

An increasing prevalence of diabetes between the 2005 and 2013–2014 KNHANES was observed in individuals between the ages of 10 to 19, with the exception of individuals who were 20–29 years old. Similarly, the prevalence of pre-diabetes rapidly increased between the 2005 and 2013–2014 KNHANES among all age groups (Fig. 1). Among teenagers (10–19 years old), the

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prevalence of diabetes increased six-fold from 0.1% in the 2005 KNHANES to 0.6% in the 2013–2014 KNHANES, and the prevalence of pre-diabetes significantly increased from 0.6% in the 2005 KNHANES to 25.9% in the 2013–2014 KNHANES. These results indicate that the prevalence of diabetes and pre-diabetes during the last decade is increasing more rapidly among teenagers (10–19 years old).

The overall prevalence of diabetes among 20–29-year-old individuals was much higher, compared to the prevalence among 10–19-year-old individuals (0.9% vs. 0.2%). However, 10–19-year-old individuals exhibited higher prevalence of pre-diabetes, compared to 20–29-year-old individuals, during the 2005, 2010–2012, and 2013–2014 KNHANES cycles except the 2007–2009 KNHANES cycle.

Prevalence of diabetes and pre-diabetes during KNHANES 2005–2014 according to obesity status

Fig. 2 and Supplementary Table 1 show the overall changes in the prevalence of diabetes and pre-diabetes among obese Korean individuals during the four KNHANES cycles. The overall prevalences of diabetes and pre-diabetes among obese 10–19-year-old individuals were 1.6% and 23.6%, respectively. The overall prevalences of diabetes and pre-diabetes among obese 20–29-year-old individuals were 2.2% and 19.3%, respectively. The prevalence of diabetes among obese 10–29-year-old individuals generally increased during the study period. Obese individuals from all age groups exhibited rapid increases in the prevalence of pre-diabetes between the 2005 KNHANES and the 2013–2014 KNHANES. During the 2013–2014 KNHANES, the prevalences of diabetes and pre-diabetes among obese 10–29-year-old individuals were 3.0% and 30.2%, respectively. The prevalences of diabetes and pre-diabetes were 2.8% and 28.0%, respectively among the obese 20–29-year-old individuals.

The overall age-standardized prevalences of diabetes and pre-diabetes among non-obese 10–19-year-old individuals were 0.1% and 12.4%, respectively (Supplementary Table 2). The prevalence of pre-diabetes among non-obese 10–19-year-old and 20–29-year-old individuals increased rapidly from the 2005 KNHANES to the 2013–2014 KNHANES. Obese 10–29-year-old individuals exhibited a 7-fold higher prevalence of diabetes during the study period compared to the prevalence of diabetes among non-obese 10–29-year-old individuals (2.1% vs. 0.3%). The prevalence of pre-diabetes among obese 10–29-year-old individuals was 1.9-fold higher, compared to the prevalence of pre-diabetes among non-obese 10–29-year-old individuals (20.3% vs. 10.5%). Compared to the non-obese 10–19-year-old individuals, the obese 10–19-year-old individuals exhibited much higher prevalences of diabetes (1.6% vs. 0.1%) and pre-diabetes (23.6% vs. 12.4%) during the four KNHANES cycles.

Awareness and management of diabetes during KNHANES 2005–2014

Table 3 shows the trends in the awareness and management of diabetes among Koreans. The 10–19-year-old group mostly had not available (NA) values, where the numbers of corresponding cases were less than five per study period. The overall rates of diabetes awareness during KNHANES 2005–2014 were 36.6% among 10–19-year-old individuals, 50.8% among 20–29-year-old individuals. However, each age group exhibited declining awareness of diabetes from the 2005 KNHANES to the 2013–2014 KNHANES. For example, diabetes awareness among 20–29-year-old individuals decreased from 84.9% in the 2005 KNHANES to 18.0% in the 2013–2014 KNHANES. Furthermore, 22.0% of 10–19-year-old individuals were aware of their diabetes status in the 2013–2014 KNHANES.

The overall percentages of insulin treatment were 6.9% among 10–19-year-old individuals and 7.5% among 20–29-year-old individuals during the study period. The percentage of insulin treatment among 10–29-year-old individuals decreased from 18.8% in the 2005 KNHANES to 3.5% in the 2013–2014 KNHANES. The overall rates of medication treatment were 19.5% and 9.0%, among the 10–19-year-old individuals and 20–29-year-old individuals, respective during the study period.

When a HbA1c level of < 6.5% (47 mmol/mol) was used to

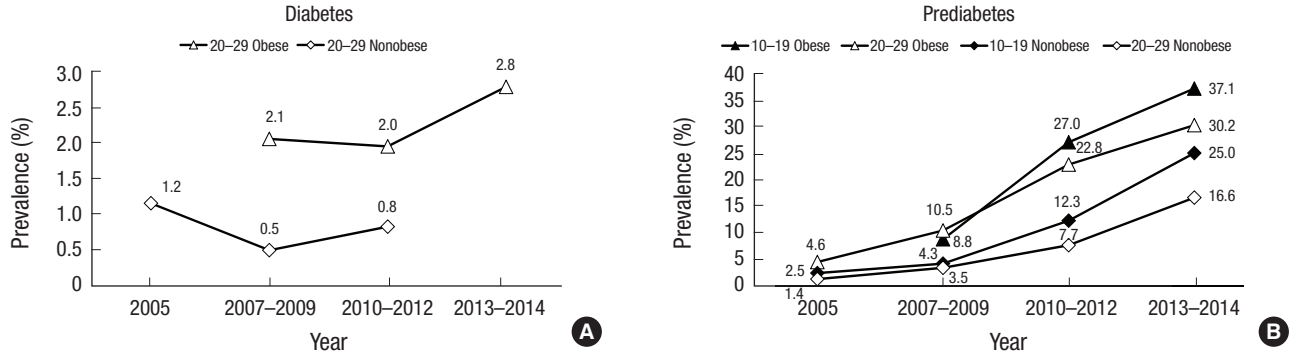

Fig. 2. Prevalence of diabetes and pre-diabetes during the four KNHANES cycles according to obesity status. (**A**) prevalence of diabetes, (**B**) prevalence of pre-diabetes.
KNHANES = Korea National Health and Nutrition Examination Survey.

Table 3. Changes in awareness and management status of diabetes in Korean youth (aged between 10 and 30) years in KNHANES 2005–2014

History on diabetes	KNHANES year				
	2005	2007–2009	2010–2012	2013–2014	2005–2014
Awareness by age, yr					
10–19	NA	5,711 (68.5)	2,797 (42.8)	7,473 (22.0)	4,807 (36.6)
20–29	31,070 (84.9)	38,443 (63.9)	38,156 (52.5)	9,945 (18.0)	30,769 (50.8)
10–29	34,319 (86.2)	44,154 (64.5)	40,953 (51.7)	17,418 (19.5)	35,576 (48.2)
Insulin treatment by age, yr					
10–19	NA	NA	NA	3,159 (9.3)	743 (6.9)
20–29	7,220 (19.7)	7,167 (11.9)	4,509 (6.2)	NA	4,549 (7.5)
10–29	7,220 (18.8)	7,167 (11.7)	4,509 (5.7)	3,159 (3.5)	5,292 (7.4)
Medication treatment by age, yr					
10–19	NA	NA	NA	7,473 (22.0)	2,141 (19.5)
20–29	8,237 (22.5)	7,212 (12.0)	6,617 (9.1)	NA	5,426 (9.0)
10–29	11,486 (28.8)	7,212 (11.8)	6,617 (8.4)	7,473 (8.4)	7,566 (10.6)
Controlled HbA1c < 7.0% (53 mmol/mol) by age, yr					
10–19	NA	NA	NA	NA	NA
20–29	NA	16,546 (55.5)	18,195 (55.9)	NA	12,668 (56.0)
10–29	NA	18,085 (57.7)	20,992 (59.4)	NA	14,107 (54.7)
Controlled HbA1c < 6.5% (47 mmol/mol) by age, yr					
10–19	NA	NA	NA	NA	NA
20–29	NA	9,622 (32.3)	18,195 (55.9)	NA	10,631 (47.0)
10–29	NA	9,622 (30.7)	20,992 (59.4)	NA	11,618 (45.0)

Values are presented as number of participants (%).
KNHANES = Korea National Health and Nutrition Examination Survey, NA = not available (less than five valid cases), HbA1c = glycated haemoglobin.

define adequate glucose control suggested by KDA, the rates of adequate glucose control among known cases of diabetes were 45.0% for 10–29-year-old individuals. When a HbA1c level of < 7.0% (53 mmol/mol) was used as the cut-off recommended by EASD and ADA, the rates of adequate glucose control were 54.7% for 10–29-year-old individuals.

DISCUSSION

There are few published studies regarding the prevalence of diabetes and pre-diabetes among teenagers and young adults (< 30 years old) (2,5,17,18). To the best of our knowledge, the present study is the first to evaluate the prevalence and management of diabetes and pre-diabetes among young Koreans (10–29 years old). Our results indicate that the prevalence of diabetes and pre-diabetes has rapidly increased among 10–29-year-old Koreans during the last 10 years, and that younger Koreans had lower awareness of diabetes. Particularly, the prevalence of pre-diabetes substantially increased (from 0.3% to 19.2%) among 20–29-year-old Koreans during last decade, while their awareness of diabetes declined (from 84.9% to 18.0%). The reasons for these dramatic changes are unclear, but we suspect that a rapid lifestyle change toward Westernization in young Korean generation (19) and the fact that 18–29-year-old Koreans are exempted from the national routine health check program might have contributed to these changes.

According to the 2015 Korean diabetes fact sheet, the total number of 0–18-year-old individuals with type 1 diabetes has decreased slightly (2006: 5,531 persons, 2013: 5,007 persons), although the corresponding incidence of type 2 diabetes has been steadily increasing (17,770 persons in 2006 to 21,327 persons in 2013) (20). In that survey (2002–2013), individuals with diabetes mellitus were identified using International Statistical Classification of Diseases codes (version 10; E10–E14) from records in the Korean National Health Information Database. Unfortunately, KNHANES data could not be used to distinguish between cases of type 1 and type 2 diabetes, which precluded a similar analysis in the present study. However, our findings of a decreasing trend in insulin treatment and an increasing number of obese people with diabetes (from the 2005 KNHANES to the 2013–2014 KNHANES) may indirectly reflect a rapid increase in the prevalence of type 2 diabetes in Korea.

A study based on the young population in five regions of US during 2009 found that the prevalence of type 1 diabetes was higher than the prevalence of type 2 diabetes among < 19-year-old individuals (type 1 diabetes: 1.93/1,000 population, type 2 diabetes: 0.46/1,000 population) (2). The same study also found that the prevalence of type 1 and type 2 diabetes increased between 2001 and 2009 among ≤ 19-year-old individuals. However, the percent increase in the prevalence was greater for type 2 diabetes (30%), compared to the increase in the prevalence of type 1 diabetes (21%) (2). According to the SEARCH for diabetes in youth study, the prevalence of diabetes among < 20-year-old Americans was 2.2/1,000 population in 2009, and this finding was largely related to an increase in the prevalence of type 1 diabetes (17). However, subgroup analysis of the SEARCH co-

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hort revealed that the prevalences of overweight status and obesity were 10.4% and 79.4%, respectively, among < 20-year-old Americans with type 2 diabetes (5). A single-centre study in South India (1992–2009) also found that the percentage of young participants with diabetes (≤ 25 years old at onset) increased dramatically from 0.6% in 1992 to 2.5% in 2009, and that 1,262 of these participants (48%) had type 2 diabetes (21).

Compared to type 1 diabetes, there are fewer data regarding the global prevalences, incidences, and clinical characteristics of type 2 diabetes among teenagers and young adults from different races and cultures. In this context, the increasing prevalence of type 2 diabetes seems to be linked to increasing rates of obesity, physical inactivity, and excessive nutrition. However, the increasing obesity among young people with type 1 diabetes makes it difficult to clinically distinguish between obese young people with type 1 and type 2 diabetes (4). Compared to adult cases of type 2 diabetes, young people with type 2 diabetes exhibit a rapid decline in β-cell function (10,14,22), more frequent treatment failure (23), earlier onset of diabetes complications, and greater mortality (13). Furthermore, in Asian countries, the onset age of diabetes is shifting towards younger ages with deteriorated lifestyle changes and more visceral fat within the same BMI ranges compared with Westerners (24). In this study, we found that the prevalence of pre-diabetes among 10–29-year-old Koreans increased from 0.4% in the 2005 KNHANES to 22.4% in the 2013–2014 KNHANES, which suggests that there will be a significant short-term shift in the economic and social burden of diabetes in Korea.

Our findings regarding the increasing prevalence of diabetes and pre-diabetes among Korean teenagers and young adults highlights an important impending crisis. This is because young people with diabetes will enter adulthood with many significant barriers, such as prolonged durations of diabetes, greater risks of early complications, higher mortality, and few approved therapies with high treatment failure rates. In Korea, the government currently provides free health screening with fasting blood glucose measurements for younger students (middle school and high school) and adults who are > 40 years old (25). However, 18–29-year-old individuals are not included in these screening efforts. Therefore, we recommend that interventions be developed to screen high-risk group of diabetes. In addition, an integrated childhood obesity prevention program in school setting needs to be developed to promote more physical activity, healthy eating and less sedentary life style. This program also needs to develop tools to screen high-risk group for diabetes as well as education for both children and their parents.

The present study has several limitations. First, we were unable to classify cases of diabetes as type 1 or type 2 diabetes, as the KNHANES questionnaire does not make this distinction. Second, approximately 17% of the survey responses were excluded from the analysis due to missing information about their fasting glucose or HbA1c levels. Third, there was a relatively small sample size for 10–30-year-old individuals in the original KNHANES design, which may create the possibility of sampling bias. In order to avoid unexpectedly inflated results, we analysed variables with at least five valid counts in each age group. However, this small sample size also resulted in many NA values regarding the awareness and management status of diabetes (Table 3), which hinders appropriate interpretation. Therefore, our findings on the awareness and management status of youth diabetes should be considered only in terms of trend over the past 10 years, and more studies are needed to confirm these findings.

In conclusion, the prevalence of diabetes and pre-diabetes is rapidly increasing among Korean teenagers and young adults. Therefore, interventions are needed to diagnose and treat pre-diabetes/diabetes, and to improve glycaemic control, in this high-risk population subgroup. It is necessary for the Korean government to expand the coverage of national health-check screening to young adults in twenties, and to develop policies promoting education for healthy dietary behaviours and physical activity for young Korean adults.

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DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Conceptualization: Cho EH, Hur J. Data curation: Hur J. Formal analysis: Hur J. Investigation: Shin D, Cho KH. Writing - original draft: Cho EH. Writing - review & editing: Cho EH, Shin D, Cho KH, Hur J.

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Supplemenatary Table 1. Changes in prevalence of diabetes and pre-diabetes among obese Koreans aged between 10 and 30 years in KNHANES 2005–2014

Diabetic groups by age	KNHANES year				
	2005	2007–2009	2010–2012	2013–2014	2005–2014
No. (total)	2,558,669	12,120,578	12,798,822	13,266,145	11,504,573
Prevalence of diabetes by age, yr					
10–19	NA	NA	NA	NA	7,029 (1.6)
20–29	NA	32,695 (2.1)	29,257 (2.0)	43,282 (2.8)	30,555 (2.2)
10–29	NA	34,352 (1.7)	35,791 (1.8)	61,282 (3.0)	37,584 (2.1)
Prevalence of pre-diabetes by age, yr					
10–19	NA	40,615 (8.8)	135,867 (27.0)	189,557 (37.1)	105,198 (23.6)
20–29	9,664 (4.3)	173,669 (11.0)	320,384 (21.4)	433,147 (28.0)	267,210 (19.3)
10–29	15,597 (4.6)	214,284 (10.5)	456,251 (22.8)	622,705 (30.2)	372,408 (20.3)

Values are presented as number of participants (%).
KNHANES = Korea National Health and Nutrition Examination Survey, NA = not available (less than five valid cases).

Supplementary Table 2. Changes in prevalence of diabetes and pre-diabetes among non-obese Korean aged between 10 and 30 years in KNHANES 2005–2014

Diabetic groups by age	KNHANES year				
	2005	2007–2009	2010–2012	2013–2014	2005–2014
No. (total)	6,429,723	31,133,829	31,782,679	32,344,451	28,741,322
Prevalence of diabetes by age, yr					
10–19	NA	NA	NA	NA	5,946 (0.1)
20–29	10,657 (1.2)	27,427 (0.5)	43,409 (0.8)	NA	27,451 (0.6)
10–29	10,657 (0.5)	34,103 (0.3)	44,082 (0.4)	27,857 (0.3)	33,397 (0.3)
Prevalence of pre-diabetes by age, yr					
10–19	32,509 (2.5)	261,276 (4.3)	734,520 (12.3)	1,357,501 (25.0)	659,325 (12.4)
20–29	12,618 (1.4)	191,692 (3.5)	404,630 (7.7)	837,182 (16.6)	397,659 (8.4)
10–29	45,127 (2.0)	452,968 (3.9)	1,139,150 (10.2)	2,194,683 (21.0)	1,056,984 (10.5)

Values are presented as number of participants (%).
KNHANES = Korea National Health and Nutrition Examination Survey, NA = not available (less than five valid cases).

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